

# MONTHLY WEATHER REVIEW.

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The MONTHLY WEATHER REVIEW is based on data from about 3500 land stations and many ocean reports from vessels taking the international simultaneous observation at Greenwich noon.

Special acknowledgment is made of the data furnished by the kindness of cooperative observers, and by Prof. R. F. Stupart, Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Secretary, Meteorological Office, London; H. H. Cousins, Chemist, in

charge of the Jamaica Weather Office; Señor Anastasio Alfaro, Director of the National Observatory, San José, Costa Rica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba.

As far as practicable the time of the seventy-fifth meridian, which is exactly five hours behind Greenwich time, is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e. apparent gravity at sea level and latitude 45°.

## SPECIAL ARTICLES, NOTES, AND EXTRACTS.

### STRUCTURE OF HAILSTONES.

By MR. E. S. WEBSTER. Dated Hutchinson, Kans., April 2, 1906.

On page 445 of the MONTHLY WEATHER REVIEW for October, 1905, in a paragraph headed "Structure of Hailstones," there was a request to observers to make observations as to whether a hailstone gave up a bubble of air when melting in water: so during quite a severe hailstorm which occurred here from 9 to 9:45 o'clock on the evening of March 25, 1906, I collected several hailstones, from 1 to 1½ inches in diameter, and put about 25 in clear water and 15 in soapsuds, as suggested; but not one of them gave up any air bubble in melting. The hailstones were mostly quite smooth and generally nearly round, though some were somewhat flattened, and were mostly formed with a center of white ice, then a layer of clear ice, and then the outside layer of white ice. A few were quite rough, appearing as if several small stones had been frozen on to the outside of the large ones, and were almost entirely composed of clear ice. At the beginning of the storm the stones were small, from ¼ to ½ inch in diameter, gradually increasing in size until at last they were from 1 to 1½ inches in diameter.

We shall be very glad to receive reports of similar experiments by other observers. There are three plausible hypotheses as to the origin of the snowy ice at the center of a hailstone.

(a) The hailstone may have begun with the formation of a ball of snow, and the clear ice may be a deposit of cold water, frozen a few seconds later by the cold of the surrounding atmosphere. In this case the air that is mixed with the snowy ice at the center would be compressed by the freezing of the surrounding clear ice, and would be liberated as a bubble when the hailstone is melted under water.

(b) The nucleus of the hailstone may have been at first a large drop of water, containing dissolved air, which is forced out by the process of freezing, precisely like the bubbles of air that are seen in cakes of artificial ice. Cold water can dissolve an appreciable percentage of its volume of air, all of which is extruded when water freezes; a bubble of highly compressed air might thus be formed at the center of the hailstone. If such a hailstone be melted in cold water slowly, all of this air will be redissolved, and no bubble will be seen to rise to the surface. If the stone be dissolved in hot water rapidly, or especially if the stone be crushed forcibly and quickly under water, the air may escape as a bubble without having had time to be redissolved.

(c) A hailstone formed of pure water that has had no opportunity to absorb or dissolve air can be reduced to a temperature far below freezing, but will eventually suddenly turn to ice, at which moment its temperature will rise to 32° F., and it will assume a crystalline structure, so as to resemble snow. Such a hailstone has, therefore, a snowy nucleus without any inclosed air, and on being melted under water will of course show no bubble. In fact, the central space is occupied, not by air, but by the vapor of water only, and as the pressure is very small, we may liken this to a partial vacuum.

All these three forms of hailstones, and other forms as yet unthought of, are possible; and if we could invent methods of distinguishing between these three kinds of hailstones, we should have a better knowledge of what goes on in the upper air during the formation of hail.

Those who have proper conveniences will find that the study of hailstones under polarized light gives additional information as to their crystalline structure, but has not as yet told us much about the process of formation.

As ice is a poor conductor of heat, it is worth while to make some effort to determine the temperature of the interior of a large hailstone. The external surface may safely be assumed to have the temperature of evaporation or the average wet-bulb temperature prevailing in the lower thousand feet of air through which the hail has rapidly fallen, but the center must be at a temperature more nearly corresponding to that at which the nucleus was formed. There is, therefore, a state of strain that should be revealed by polarized light. The average temperature of the whole hailstone may be easily and directly determined by allowing hail to melt within a calorimeter, where the heat consumed can be determined, and then the temperature be computed.

Before making such researches on hailstones, we must devise methods of catching them that will prevent injury or warming or even melting by reason of the shock that occurs when the hail strikes the hard ground. Probably it would be sufficient to catch the hail in the "bag gage for hail," described in the MONTHLY WEATHER REVIEW for September, 1897, Vol. XXV, p. 210, or on a bed of soft cotton, or in a barrel half full of water. Pieces of strong cloth or paper spread on water will catch a large hailstone nicely; the momentum of the hail carries the cloth downward and it is quickly wrapped about the hail.—C. A.